



Battalion Chief Suffers a Heart Attack and Eventually Dies While Participating in a Fitness Program - California

SUMMARY

On October 15, 1997, a 54-year-old male Battalion Chief (BC) experienced chest pain while exercising during his work shift. An ambulance crew transported the BC to the emergency department where he was admitted to the hospital for an acute myocardial infarction (MI), commonly known as a heart attack. He underwent emergency coronary angiography, angioplasty with stent placement, followed by the intravenous (IV) infusion of a thrombolytic agent. Although the BC tolerated this first hospitalization and procedure well, over the next 5 months he underwent multiple diagnostic and therapeutic cardiac procedures with numerous complications. He ultimately died on April 29, 1998. The death certificate, completed by the State Medical Examiner, listed "Cardiogenic Shock due to Enterobacter sepsis due to Multi-organ Failure due to Ischemic Cardiomyopathy" as the immediate cause of death. No autopsy was performed.

Other agencies have proposed a three-pronged strategy for reducing the risk of on-duty heart attacks and cardiac arrests among fire fighters. This strategy consists of: 1) minimizing physical stress on fire fighters; 2) screening to identify and subsequently rehabilitate high risk individuals; and 3) encouraging increased individual physical capacity.

Issues relevant to this fire department include:

- ***The Fire Department should modify the content and frequency of their fire fighters annual medical evaluations to match that recommended by National Fire Protection Association (NFPA) 1582 (Medical Requirements for Fire Fighters).***

- ***The Fire Department physician, not personal or consulting physician, should have the responsibility of determining medical clearance for a fire fighter's unrestricted return to work status.***
- ***Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by phasing in a mandatory wellness/fitness program for fire fighters.***
- ***Perform an autopsy on all on-duty fire fighter fatalities.***
- ***Leave doors to personal quarters unlocked in case of emergency.***

INTRODUCTION AND METHODS

On October 15, 1997, a 54-year-old male Battalion Chief (BC) experienced severe chest pain while participating in a Fire Department (FD) sponsored fitness program. He was transported by ambulance

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at www.cdc.gov/niosh/firehome.html or call toll free 1-800-35-NIOSH



Fatality Assessment and Control Evaluation Investigative Report #F2000-15

Battalion Chief Suffers a Heart Attack and Eventually Dies While Participating in a Fitness Program - California

to a local hospital where an acute MI was diagnosed and he underwent emergency coronary angiography, and angioplasty with stent placement, followed by the IV infusion of a thrombolytic agent. Although the BC tolerated this first hospitalization and procedure well, over the next 5 months he underwent a series diagnostic and therapeutic cardiac procedures complicated by many problems to which he ultimately succumbed on April 29, 1998. NIOSH was notified of this fatality by the USFA. On February 14, 2000, NIOSH contacted the affected Fire Department to initiate the investigation. On March 1, 2000, an Epidemiologist from the NIOSH Fire Fighter Fatality Investigation Team traveled to California to conduct an onsite investigation of the incident.

During the investigation NIOSH personnel met with and interviewed:

- The Fire Chief;
- Deputy Chiefs;
- The Local President of the International Association of Fire Fighters (IAFF);
- The contract Physician to the department;
- Crew members involved in this incident;
- Victim's wife;
- County Risk Management personnel.

During the site-visit NIOSH personnel also reviewed:

- Existing FD investigative records, including the board of inquiry report, incident reports, co-worker statements, and dispatch records;
- The victim's fire department training records;
- Emergency medical services - ambulance report;
- Pertinent hospital records;
- Death certificate;
- Past medical records of the deceased;
- FD policies and operating procedures;
- FD training records;
- The FD annual run report for 1999.

INVESTIGATIVE RESULTS

Incident Response. On October 15, 1997, late in the afternoon, the BC engaged in strenuous exercise on a Stairmaster as a part of a FD fitness program. During this exercise, other fire fighters noted his unusually pale and sweaty appearance. After exercising, the BC returned to his personal quarters. At approximately 2145 hours, he called the main fire station phone line and requested that Firemen call an ambulance for his severe chest pain. The other Firemen went to assist the BC with their "jump kit" and resuscitator, but found his quarter's door locked. After a brief period (approximately 1 minute) the BC unlocked and opened the door, and the other Firemen noted his ashen and diaphoretic (sweaty) appearance. He complained of shortness of breath, nausea, and having a slight pain in his chest and neck area. Vital signs were taken by the firemen, and they placed an oxygen mask over the BC's nose and mouth. The ambulance arrived at 2155 hours and the paramedics noted the BC to be alert and oriented. The paramedics took the BC's vital signs and administered a sublingual (under the tongue) nitroglycerin pill and an aspirin while an IV line was established. A second sublingual nitroglycerin was given and oxygen was continued while an oximeter reported 94% oxygen saturation (normal). The BC arrived at the hospital at 2223 hours with persistent chest pain. His vital signs were stable and an electrocardiogram (EKG) revealed T-wave inversions in the inferior leads consistent with ischemia (lack of oxygen) to the heart. His chest pain was unrelieved by an IV nitroglycerin drip and administration of morphine, and at 2337 hours he was taken to the cardiovascular laboratory for a cardiac catheterization. This test revealed:

- 90% narrowing of the left anterior descending (LAD) artery proximal to the 1st diagonal;
- Total occlusion (thrombus or blood clot) of the LAD distal to the 1st diagonal;
- 90% narrowing of the 1st diagonal;
- 99% stenosis of the proximal circumflex;



Fatality Assessment and Control Evaluation Investigative Report #F2000-15

Battalion Chief Suffers a Heart Attack and Eventually Dies While Participating in a Fitness Program - California

- 50-60% stenosis of the mid-circumflex;
- 60% narrowing of the right coronary artery.
- Left ventricular ejection fraction was approximately 45% with anterior wall hypokinesis.

Due to these findings, emergency percutaneous transluminal coronary angioplasty (PCTA) was performed with stent placement at the 90% proximal LAD lesion, followed by the IV infusion of a thrombolytic agent. These procedures limited the infarct's size determined by EKG changes (non Q-wave) and modest elevation of the creatine phosphokinase (CK) MB isoenzymes. The BC tolerated the procedure well, and was discharged on October 19, 1997.

The BC had a follow-up echocardiograph on October 20, 1997 which showed a left ventricular ejection fraction of 60% with mild anterior wall hypokinesis. A thallium exercise stress test (EST) on November 10, 1997 was conducted for 10.5 minutes, achieving 94% of the maximum predicted heart rate and 15.2 METS on the Bruce protocol. Although the BC did not report any chest pain, the EKG was "possibly" positive for ischemia in the inferior leads. The thallium scan showed a reversible defect in the posterior wall suggesting mild ischemia, and an anteroapical segment abnormality of unknown significance.

On November 17, 1997 the BC had PCTA and a stent placed in both the proximal and distal lesions in the circumflex artery. This was successfully performed, but it was noted that he had 60% stenosis of the obtuse marginal vessel and would have to have another angioplasty in the future.

On January 12, 1998, the BC had another attempt at opening his coronary artery lesions by PCTA, but these were unsuccessful and he was referred for possible coronary artery bypass graft (CABG)

surgery. On January 22, 1998 the victim presented in the emergency room with severe chest pain which rapidly deteriorated into cardiogenic shock. Cardiac catheterization showed complete occlusion of his LAD and circumflex arteries at the stents. He underwent emergency CABG. His post-operative course over the next three months was filled with complications including severe congestive heart failure, renal failure requiring dialysis, respiratory failure, recurrent intrathoracic bleeding, sternal wound infection, and sepsis. He died on April 29, 1998 awaiting for his medical problems to resolve prior to being a candidate for a heart transplant.

Medical Findings. The death certificate was completed by the Hospital Medical Examiner, who listed "Cardiogenic Shock due to Enterobacter sepsis due to Multi-organ Failure due to Ischemic Cardiomyopathy" as the cause of death. No autopsy was performed. His carboxyhemoglobin level was not checked due to the location of the onset of symptoms being at the fire station. Past Fire Department medical records indicated that the victim had five known risk factors (male gender, age over 45, family history of premature coronary artery disease (CAD), diabetes, and high cholesterol) for CAD.

In 1972, the victim had an episode of left-sided chest pain evaluated with an EST, which was interpreted as negative for CAD. In May 1996, under the Fire Department's medical screening program, the BC underwent another EST. The BC reached an energy expenditure of 8.2 METS (9 minutes on the Balke protocol) but was unable to complete the test due to fatigue. The FD, following NFPA 1582 guidelines, requires fire fighters achieve 10.0 METS to be cleared for unrestricted duty, so the FD physician placed the victim on light duty and instructed him to increase his exercise level. A repeat EST was conducted in September 1996; he reached a level of 7.72 METS (9 minutes on the Balke protocol) but he developed



Fatality Assessment and Control Evaluation Investigative Report #F2000-15

Battalion Chief Suffers a Heart Attack and Eventually Dies While Participating in a Fitness Program - California

EKG changes (a reported 1 mm horizontal ST segment depression in leads II, III, AVF, V4 through V6) without chest pain and with no drop in blood pressure. He remained in a light duty assignment and was placed in a mandatory fitness program. In December 1996, the Fire Department contract physician ordered another exercise stress test (EST), in which the BC attained 9.36 METS (11 minutes on the Balke protocol) with the same EKG changes and no chest pain and no drop in blood pressure. On December 18, 1996, the BC had a consultation with a cardiologist, and at that time, appeared to want to proceed with coronary angiography. However, prior to that procedure, the BC had one more EST at a referral hospital in January 1997. He exercised for a total of 13 minutes on the Bruce protocol, reaching an estimated 15 METS without chest pain or drop in blood pressure. The summary sheet of this EST did not report the EKG changes noted at the September and December test. In addition, the complete January 1997 EST tracings were not available for NIOSH review at the time of this report. Based on this new information, the contract physician from the FD cleared the BC for unrestricted duty in January, 1997.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the fire department was comprised of 438 uniformed personnel and served a population of 650,000 residents, in a geographic area of 8060 square miles. There are 46 fire stations where fire fighters work the following tour of duty: 48 hours on, 48 hours off, 48 hours on, 48 hours off, 48 hours on, 192 hours off. Each shift of an engine company is staffed with an officer, an engineer, and one or two fire fighters. Each shift of a ladder company is staffed with an officer, an engineer, and fire fighters. The incident occurred during an overtime shift on the second day. Throughout the day, the victim did not report any

signs of discomfort, pain, or distress. The BC was noted to have an unusually pale and sweaty appearance while exercising. The victim went on one response, to a spot grass fire at 1940 hours that day, prior to exercising.

In 1999, the department responded to 29,821 total calls: 289 medical calls, 42 emergency landings, 113 hazardous materials calls, 2,781 hazardous conditions, 216 "improvement fires", 16,167 medical aid calls, 2,151 public service calls, 483 refuse fires, 1,933 rescue calls, 1,908 structure fires, 920 unclassified calls, 1,680 vegetation fires, and 1,138 vehicle fires. The emergency medical service is operated by private companies.

Training. The fire department provides all new fire fighters with the basic 11-week recruit training conducted at the county Drill School to become certified to the National Fire Protection Association (NFPA) Fire Fighter I level. All are State-certified Emergency Medical Technicians. The department also conducts monthly training. The victim had approximately 30 years of fire fighting experience and was a NFPA-certified Fire Officer.

Pre-employment/Pre-placement Evaluations. The department requires a pre-employment/pre-placement medical evaluation for all new hires, regardless of age. The components are set forth in an agreement between the fire department and the contract physician. Components of this evaluation for all applicants include:

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Vision test
- Audiogram
- Complete blood count (CBC) with differential
- Blood lipid profile (total cholesterol, HDL cholesterol, triglycerides)



Fatality Assessment and Control Evaluation Investigative Report #F2000-15

Battalion Chief Suffers a Heart Attack and Eventually Dies While Participating in a Fitness Program - California

- Blood chemistries (30 items)
- Urinalysis
- Hemocult
- Fasting glucose level
- Chest X-ray
- Exercise electrocardiogram (EST)
- Pulmonary function test/Spirometry
- Stool guiac test (test for blood in the stool)
- Percentage body fat (using calipers)
- Colon esterase
- Pap smear (for females)
- Mammogram (for females over 35)
- Blood lipid profile (total cholesterol, HDL cholesterol, triglycerides)
- Blood chemistries (30 items)
- Prostate-specific antigen (PSA, for males 45 and older)
- Urinalysis
- Fasting glucose levels
- Chest X-ray (smokers - every year; non-smokers \leq 45 years old - every three years; non-smokers $>$ 45 years old - every year)
- HAZMAT team members)
- Exercise electrocardiogram (EST)
- Pulmonary function test/Spirometry
- Sigmoidoscopy ($>$ 50 years old - every three years)
- Stool guiac
- Pap smear (for females if requested)
- Mammogram (for females over 35 if requested)

These evaluations are performed by a contract physician hired by the County Fire Department. Once this evaluation is complete, a decision regarding medical clearance for fire fighting duties is made by the examining physician. New hires are also required to complete a timed performance evaluation of typical fire fighting duties. Finally, medical clearance for SCBA use is determined by the contract physician from the results of this medical evaluations. If the member has a disqualifying condition, the individual, the Department physician and the Return- To- Work Coordinator devise a rehabilitation plan specific to the needs of the individual while observing all patient confidentiality.

Periodic Evaluations

Medical evaluations are required by this FD on a periodic basis (every 2 years until age 50 and every year thereafter including HAZMAT Team members and individuals identified by the Department physician). Components of this evaluation for all firefighters include:

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Vision test
- Audiogram
- Complete blood count (CBC)

These evaluations are performed by a contract physician hired by the County FD. Once this evaluation is complete, a decision regarding medical clearance for fire fighting duties is made by the examining physician. Medical clearance for SCBA use is determined by the contract physician on an annual basis from the results of this annual medical evaluation by the Fire Department contract physician. If an employee is injured at work, he/she must be cleared for “return to work” by the contract physician. There is a voluntary fitness/wellness program which becomes a required fitness/wellness program if the fire fighter is not able to reach the required 10 METS on the EST. All stations have exercise (strength and aerobic) equipment, purchased by the local union.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.¹ Risk factors for its development include increasing age,



Battalion Chief Suffers a Heart Attack and Eventually Dies While Participating in a Fitness Program - California

male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.² The victim had five of these risk factors (male gender, family history, diabetes, age over 45, and high cholesterol), and had CAD confirmed by his heart attack in October 1997 and subsequent coronary arteriography.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.³ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.⁴ Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.⁵ This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques as seen during this victim's coronary arteriography in October, 1997, and on January 22, 1998.

Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.⁶⁻⁸ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.⁹⁻¹¹ By all accounts, the victim was performing aerobic exercise while on-duty. Prior to his heart attack, this victim did not report prior episodes of angina (heart pain) during physical activity performed on- or off-the-job. But acute myocardial infarction is often the first overt manifestation of ischemic heart disease.¹²⁻¹⁵

To reduce the risk of heart attacks and sudden cardiac arrest among fire fighters, the National Fire Protection Association (NFPA) has developed

guidelines entitled "Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians," otherwise known as NFPA 1582.¹⁶ They recommend, in addition to screening for risk factors for CAD, an exercise stress EKG, otherwise known as an exercise stress test (EST). The EST is used to screen individuals for CAD. Unfortunately, it has problems with both false negatives (inadequate sensitivity) and false positives (inadequate specificity), particularly for asymptomatic individuals (individuals without symptoms suggestive of angina), young men, and women.^{17,18} This has led other expert groups to **not** recommend EST for asymptomatic individuals without risk factors for CAD.¹⁹⁻²⁰

When these asymptomatic individuals **have** risk factors for CAD, however, recommendations vary by organization. The American College of Cardiology/American Heart Association (ACC/AHA) identifies four groups for EST although they note that the "usefulness/efficacy is less well established by evidence/opinion."¹⁹

- Group 1: Persons with multiple risk factors. They define five risk factors for CAD: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic greater than 140 mm Hg or diastolic greater than 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in 1st degree relative less than 60 years old).
- Group 2: men over the age of 40 and women over the age of 50 (especially if sedentary) who plan to start vigorous exercise.
- Group 3: men over the age of 40 and women over the age of 50 who are at high risk for CAD due to other diseases (e.g. chronic renal failure).
- Group 4: men over the age of 40 and women over the age of 50 who are involved in occupations in which impairment might impact public safety.



Fatality Assessment and Control Evaluation Investigative Report #F2000-15

Battalion Chief Suffers a Heart Attack and Eventually Dies While Participating in a Fitness Program - California

The U.S. Preventive Services Task Force (USPSTF) does not recommend EST for asymptomatic individuals, even those with risk factors for CAD; rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes).²⁰

The USPSTF indicates that there is insufficient evidence to recommend screening middle age and older men or women in the general population, however, "screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other grounds, including the possible benefits to public safety."²⁰

In this case the BC had a MI despite having a both satisfactory and unsatisfactory EST's within the proceeding year.

RECOMMENDATIONS AND DISCUSSION

The following recommendations address health and safety generally. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH, but represent research presented in the literature or of consensus votes of Technical Committees of the National Fire Protection Association or labor/management groups within the fire service. In addition, they are presented in a logical programmatic order, and are not listed in a priority manner.

Recommendation #1: The Fire Department should modify the content and frequency of their fire fighters annual medical evaluations to match that recommended by NFPA 1582 (Medical Requirements for Fire Fighters).

The FD conducts extensive pre-employment/pre-placement and periodic medical evaluations; however, the frequency and content of these evaluations differ from those recommended by the NFPA.¹⁵ NFPA recommends a yearly physical evaluation to include a medical history, height, weight, blood pressure, and visual acuity test. NFPA recommends a more thorough evaluation [medical examination, audiometry, pulmonary function testing, a complete blood count, urinalysis, blood biochemistry, and vision testing] be conducted on a periodic basis according to the age of the fire fighter (< 30: every 3 years; 30-39: every 2 years; >40 years: every year). The NFPA recommends pre-placement chest X-rays, but not periodic chest X-rays, and EST for those 35 years old and above with known CAD risk factors, and 40 years old and above for those without CAD risk factors.¹⁵

To be consistent with the NFPA 1582, the FD should omit the following tests from the pre-employment/pre-placement medical evaluation the: a) EST for fire fighter less than 35 years old; b) PSA; c) sigmoidoscopy; d) stool guiac test; e) colon esterase; f) Pap test, and g) mammogram. Tests that could be omitted on the periodic medical evaluations include the: a) PSA; b) sigmoidoscopy; c) stool guiac test; d) colon esterase; e) Pap test, and f) mammogram. In addition, the frequency of the following components of the periodic medical evaluation could be reduced: a) annual medical examination; b) EST for fire fighter less than 35 years old. While most of these tests have few harmful side effects and are valuable general health screening tools, they do represent an expense for the FD. We recommend the County and the Union negotiate the content and frequency to be consistent with these expert consensus guidelines. If the FD offers general preventive health services, in addition to examinations done for occupational health purposes, those services should be consistent with current expert recommendations, such as those of the USPSTF.



Battalion Chief Suffers a Heart Attack and Eventually Dies While Participating in a Fitness Program - California

In addition to providing guidance on the frequency and content of the medical evaluations, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks. Applying NFPA 1582 involves legal issues, so it should be carried out in a **confidential, nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for Fire Department administrators regarding legal considerations in applying the standard. Applying NFPA 1582 also involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, addresses these issues in Chapter 8-7.1 and 8-7.2.¹⁸

The success of medical programs hinges on protecting the affected fire fighter. The department must **1)** keep the medical records confidential with regard to State and Federal laws, **2)** provide alternate duty positions for fire fighters in rehabilitation programs, and **3)** if the fire fighter is not medically qualified to return to active fire fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives.

Recommendation #2: The Fire Department physician should have the final authority to determine a fire fighter's unrestricted return to work status.

Return-to-work evaluations and examinations may be performed by the department physician, the fire fighters personal physician, specialist physician, or any other physician. Information gathered at these evaluations or examinations, not just the summary reports, should be reviewed by the Fire Department physician. The final decision regarding medical clearance for returning a fire fighter back to full duty, should rest exclusively with the FD physician.

Recommendation #3: Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by phasing in a mandatory wellness/fitness program for fire fighters.

NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.¹⁸ In 1997, the International Association of Fire Fighters and the International Association of Fire Chiefs joined in a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual with a video detailing elements of such a program.¹⁷ While this FD maintains an exercise program, this program is not mandatory until a fire fighter cannot meet their medical screening and/or performance evaluation requirements (>10 METS on the EST). This FD and the Union should review the material developed by Fire Service Joint Labor Management Wellness/Fitness Initiative to identify applicable elements to implement as a mandatory fitness/wellness program. Other large-city negotiated programs can also be reviewed as potential models.

Recommendation #4: Perform an autopsy on all on-duty fire fighter fatalities.

In 1995, the United States Fire Administration (USFA) published the Firefighter Autopsy Protocol.¹⁹ This publication hopes to provide "a more thorough documentation of the causes of firefighter deaths for three purposes:

- (1) to advance the analysis of the causes of firefighter deaths to aid in the development of improved



Fatality Assessment and Control Evaluation
Investigative Report #F2000-15

Battalion Chief Suffers a Heart Attack and Eventually Dies While Participating in a Fitness Program - California

- firefighter health and safety equipment, procedures, and standards;
- (2) to help determine eligibility for death benefits under the federal government's Public Safety Officer Benefits Program, as well as state and local programs; and
- (3) to address an increasing interest in the study of deaths that could be related to occupational illnesses among firefighters, both active and retired.”

Recommendation #5: Leave doors to personal quarters unlocked in case of emergency.

The door to personal quarters should be left unlocked to facilitate entry in case of an emergency when no one inside quarters can open the door.

REFERENCES

1. Fauci AS, Braunwald E, Isselbacher KJ, et al [1998]: Harrison's Principles of Internal Medicine, 14th Edition. McGraw-Hill: New York, New York, pp. 222-225.
2. American Heart Association (AHA)[1998]. AHA Scientific Position, Risk Factors for Coronary Artery Disease, Dallas, Texas.
3. Fauci AS, Braunwald E, Isselbacher KJ, et al [1998]: Harrison's Principles of Internal Medicine, 14th Edition. McGraw-Hill: New York, New York, p. 1348.
4. Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol 20 (11 Suppl2): II-38-44.
5. Fuster V, Badimon JJ, Badimon JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. N Eng J Med 326:242-50.
6. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. J Occup Med 1975;17:247-250.
7. Manning JE, Griggs TR [1983]. Heart rate in fire fighters using light and heavy breathing equipment: Simulated near maximal exertion in response to multiple work load conditions. J Occup Med 1983;25:215-218.
8. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. J Occup Med 1977;19:558-562.
9. Willich SN, Lewis M, Lowel H, et al [1993]. Physical exertion as a trigger of acute myocardial infarction. N Eng J Med 329:1684-90.
10. Mittleman MA, Maclure M, Tofler GH, et al: [1993]. Triggering of acute myocardial infarction by heavy physical exertion. N Eng J Med 329:1677-83.
11. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. N Eng J Med 311:874-7.
12. Tofler GH, Muller JE, Stone PH, et al [1992]. Modifiers of timing and possible triggers of acute myocardial infarction in the Thrombolysis in Myocardial Infarction Phase II (TIMI II) Study Group. J Am Coll Cardiol 1992;20:1049-55.
13. Fauci AS, Braunwald E, Isselbacher KJ, et al [1998]. Harrison's Principles of Internal Medicine, 14th Edition. McGraw-Hill: New York, New York, p. 1366.
14. National Fire Protection Association [1997]. NFPA 1582, Standard on Medical Requirements for Fire Fighters. NFPA, Quincy MA.



Fatality Assessment and Control Evaluation
Investigative Report #F2000-15

Battalion Chief Suffers a Heart Attack and Eventually Dies While Participating in a Fitness Program - California

15. Gianrossi R, Detrano R, Mulvihill D, et al. [1989]. Exercise-induced ST depression in the diagnosis of coronary artery disease: a meta-analysis. *Circulation* 57:64-70.
16. National Fire Protection Association. NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians. NFPA, Quincy MA, 2000.
17. Michaelides AP, Psomadaki ZD, Dilaveris PE. Improved detection of coronary artery disease by exercise electrocardiography with the use of right precordial leads. *New Eng J Med* 1999;340:340-345.
18. Darrow MD. Ordering and understanding the exercise stress test. *American Family Physician*. January 15, 1999.
19. Gibbons RJ, Balady GJ, Beasley JW, Bricker JT, Duvernoy WFC, Froelicher VF, Mark DB, Marwick TH, McCallister BD, Thompson PD, Winters WL Jr, Yanowitz FG. ACC/AHA guidelines for exercise testing: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). *J Am Coll Cardiol*. 1997; 30:260-315.
20. U.S. Preventive Services Task Force. Guide to clinical prevention services, 2nd Ed. Baltimore, MD: Williams & Wilkins, 1996, pp. 3-15.

INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by Kristen Sexson, MPH, Epidemiologist. Ms. Sexson is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio.